Image Semantic Coding

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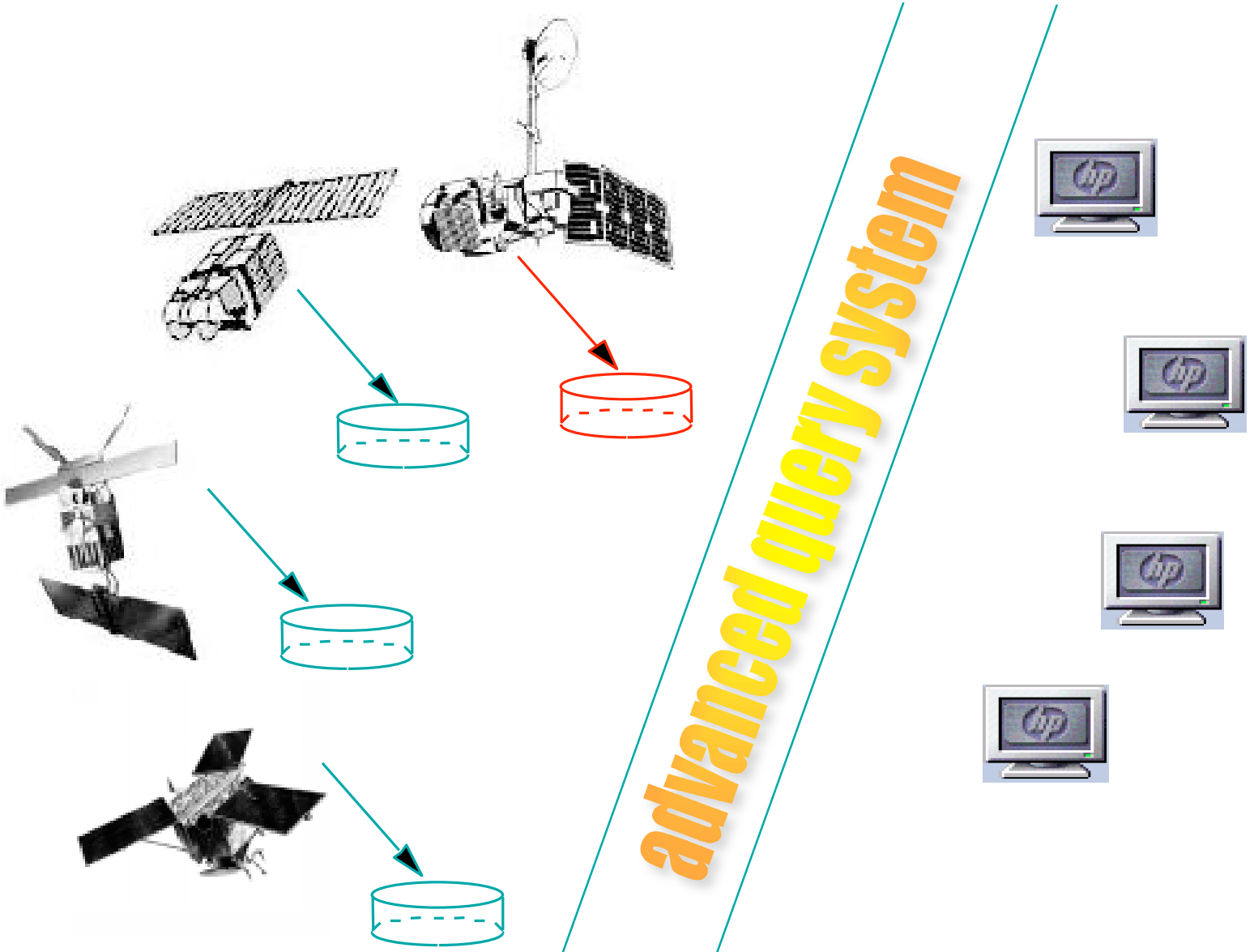
2006 NASA/Goddard Space Flight Center's
Information Science and Technology (IS&T) Colloquium Series
September 27, 2006


advanced query system

The Challenge

The past 30 years: EO data archiving resulted in huge repositories

- { 1 000 000 } multi-sensor images

Actually less than 5% of the data is used

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The next 10 years: new generations of high resolution EO sensors

A double explosion:

1. Data volumes to be acquired
2. Information details contained in the data

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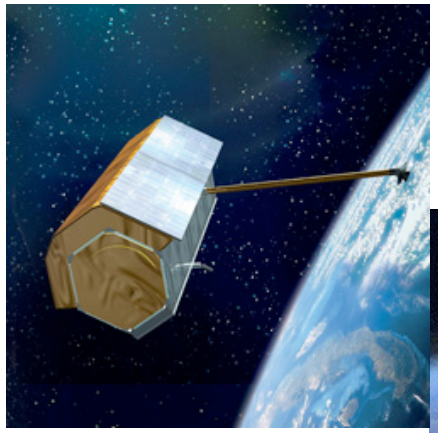
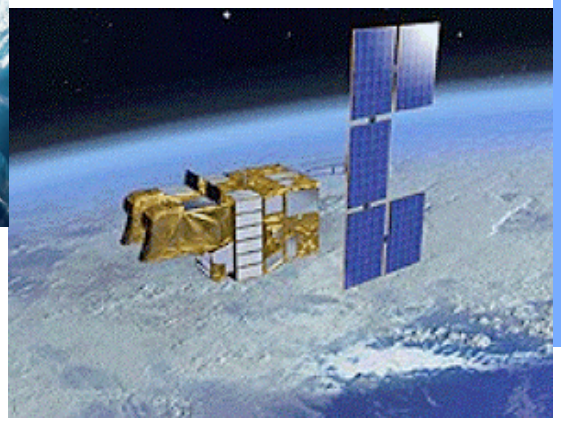


TerraSAR-X

Pléiades



≈{ 1 000 } images / day
Resolution ≈{ 10 } cm
Optical
SAR
Multimodal

New applications and users

http://www.gmes.info/

Past years: Meta-data based file access

The data archive

The meta - data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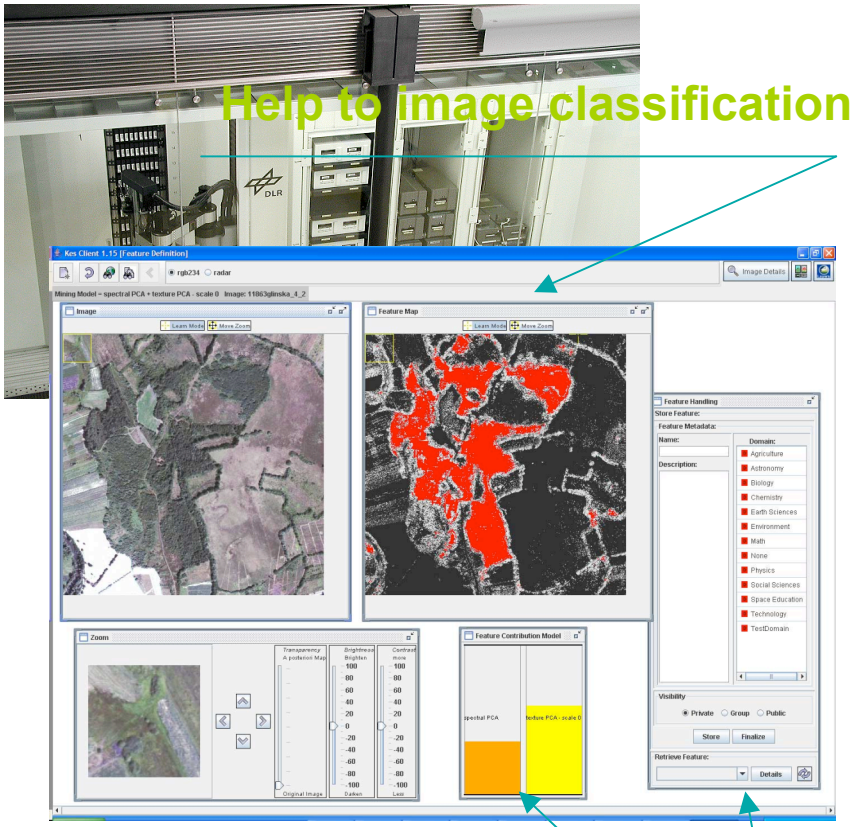
The data

Data access

Today: Interactive, user adapted, EO data content access



Mine Fields (Daedalus)

Access to:
information
knowledge

Postulates

Existing volume of unstructured data prevents any systematic exploitation of its information content.

Information extraction depends critically on the descriptive or predictive accuracy of the stochastic model employed.

The augmentation of the data with meaning, e.g. image understanding, can be interpreted as a coding task which includes the model of user's conjecture.

Paradox

People have trouble in caching more than **7 items** at a time.
We design systems to enable people to access **1000 TB**.

The KEO Vision

KEO - Knowledge centred Earth Observation

"The information extraction process must be replaced by more automated, direct and human centred methods"

Automated, Direct and Human Centred

- "Automated" is a consequence of the data size / complexity and of the cost of the non-automatic process.
- "Direct" responds to the need in order to reduce the steps between the user and the information.
- "Human centred" brings the focus on systems that could be managed also by non-EO experts via semantic interactions.

KEO - Knowledge centred Earth Observation

IIM prototype on-line:

http://kes.esrin.esa.int/kes

Documentation:

http://earth.esa.int/rtd/Tools

Publications:

http://www.vision.ee.ethz.ch/publications

Several installations

ACS, ESA, EUSC, JRC, DLR, CNES, VUB, UPB, ...

IIMCG - Image Information Mining Coordination Group

http://earth.esa.int/rtd/Events/ESA-EUSC_2006/index.html

Image Information Mining for Security and Intelligence

ESA-EUSC Conference, Madrid SPAIN, November 27-28, 2006

Image Information Mining - Project Activities

Project acronyms KIM, KIMV, KES, KEO, PIMS, IIMTS, MIMS, ...

- **KIM** **Knowledge driven Information Mining**
- **KIMV** **KIM Validation**
- **KES** **Knowledge Enabling Services**
- **KEO** **Knowledge centred Earth Observation**
- **PIMS** **Partner Image Mining System**
- **IIMTS** **IIM Time Series**
- **MIMS** **MERIS Information Mining Services**

Competence Centre on Information Extraction and Image Understanding for Earth Observation

CNES - DLR - ENST

- **Home**
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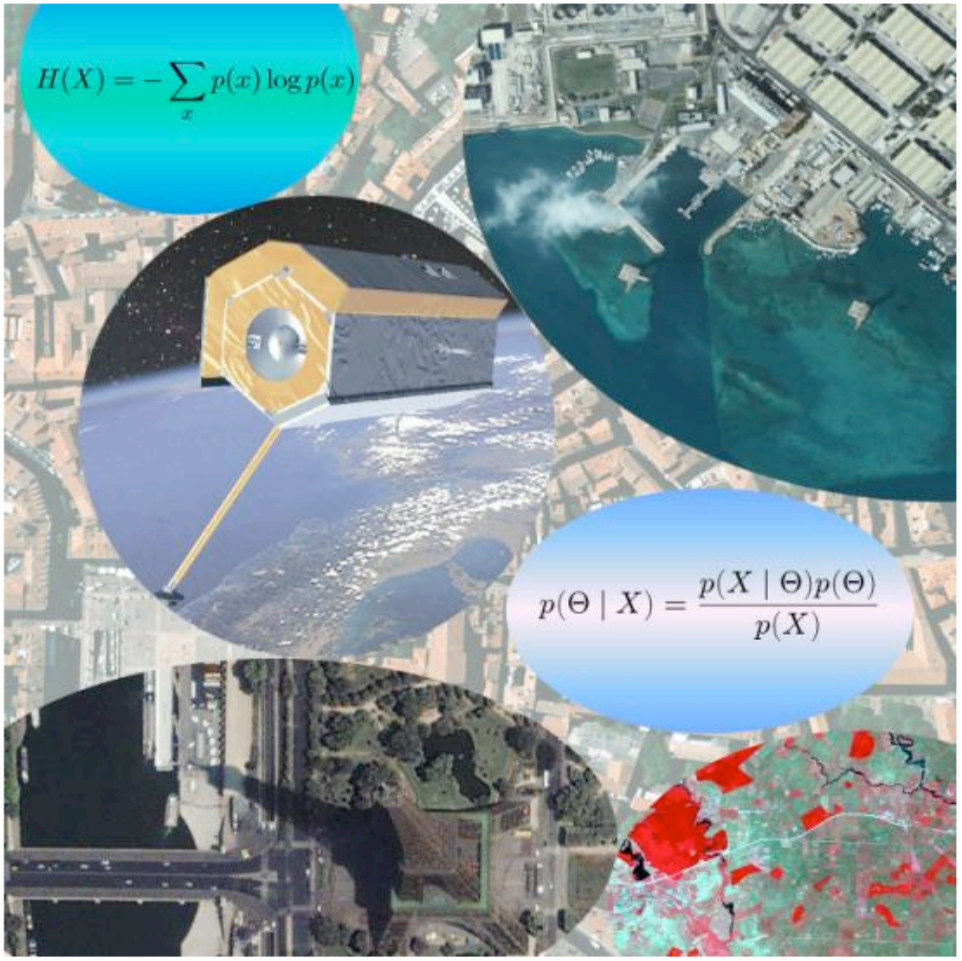
- Contact
- Coordination Commitee
- Members
- Research
- Seminar
- Publications
- Demos
- Links



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http://kes.acsys.it/kes/

Archives and Libraries

- **Archive:** a long-term storage area, place or collection containing records, documents, or other materials of historical interest (that's passive and static!)
- **Library:** a depository built to contain books and other materials ***for reading and study*** (that's active and dynamic!)

What makes the difference?

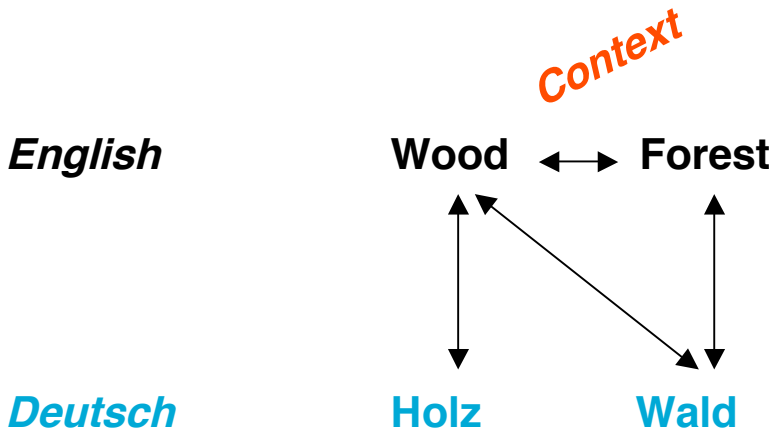
- **Library has:**
  - **A catalogue (better then archives):** indexing books based on multiple criteria, e.g. author, title, keywords, domains (ontology!)...
  - **A librarian:** one who has the care of a library and its contents, selecting the books, documents and non-book materials which comprise its collection, and providing information and loan services to meet the needs of its users

Searching Libraries

- **Use the catalogue:** select indexes and search the books. Next, read them.
- **Walk trough the library**: browse till you get interested...
- ***A friend told me***...: go to the material using prior information
- ***Ask the librarian:*** the *ideal* librarian, he
  - reads all the incoming books
  - interprets contents
  - associate with other information
  - creates categories
  - understand the inquiry
  - dialogues
  - comments, and
  - suggest ...

Searching Libraries

- **Semantics....**

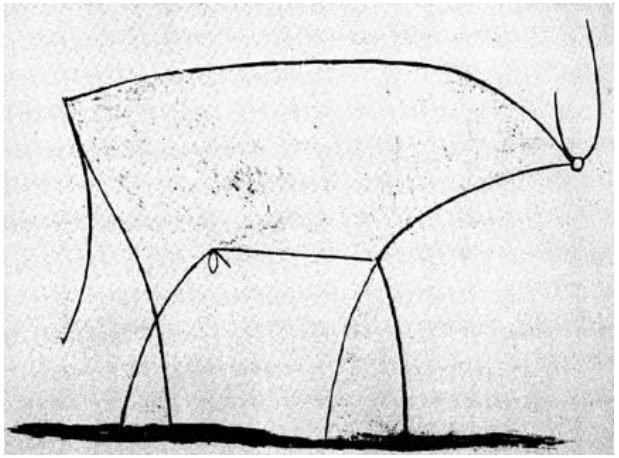


Searching Image Libraries

The picture

Librarian
Picasso

Description



Librarian
Sport fan

Description

Image semantics

- a fundamental difference of an image vs. a database record (a book) is their different status as signs
- Information in images is contextually incomplete: taken isolated, images have no assertive value but rely on some external information
- the drawback of images comes from semantic assumptions
- thus, the need for redefining the concept and role of meaning

A Mathematical Theory of Communication

By C. E. SHANNON

Introduction

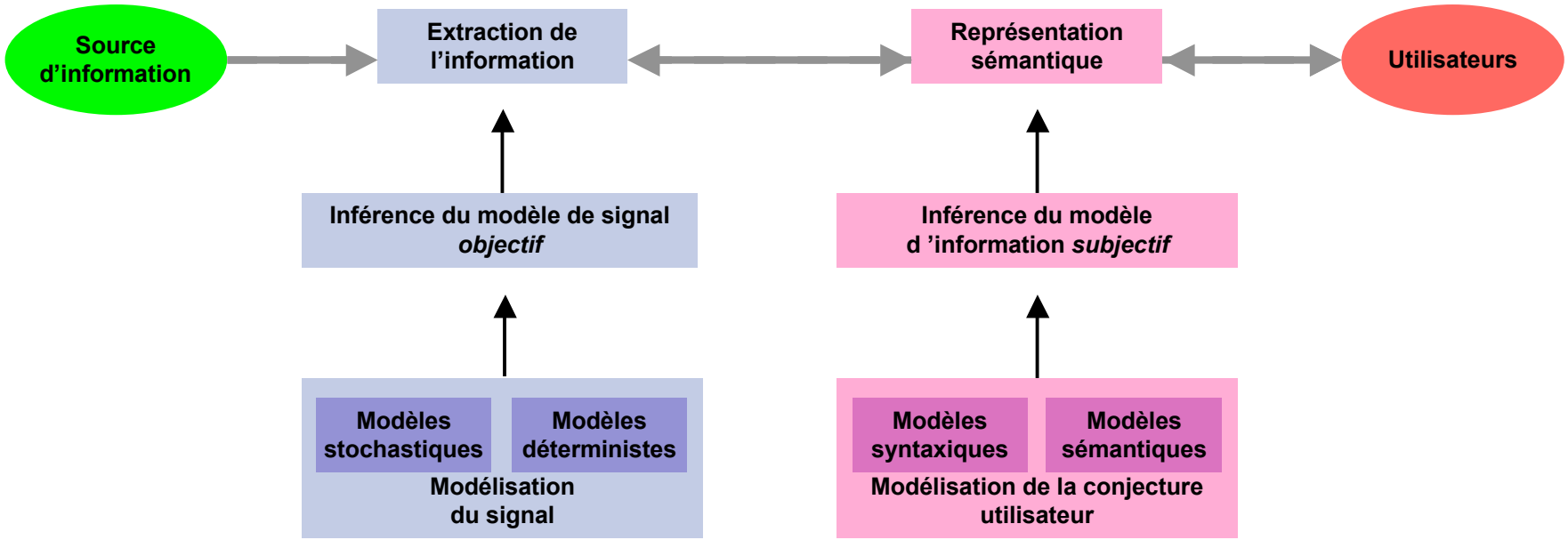
THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist[1] and Hartley[2] on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design.

Semantics

- semantics emerge (only) by interactions between human and machine
- there is a knowledge acquisition bottleneck for semantics-based applications
- learning the interactions between machine and human makes semantic emerge
- semantics in the frame of ontologies, give models that provide abstractions of the world

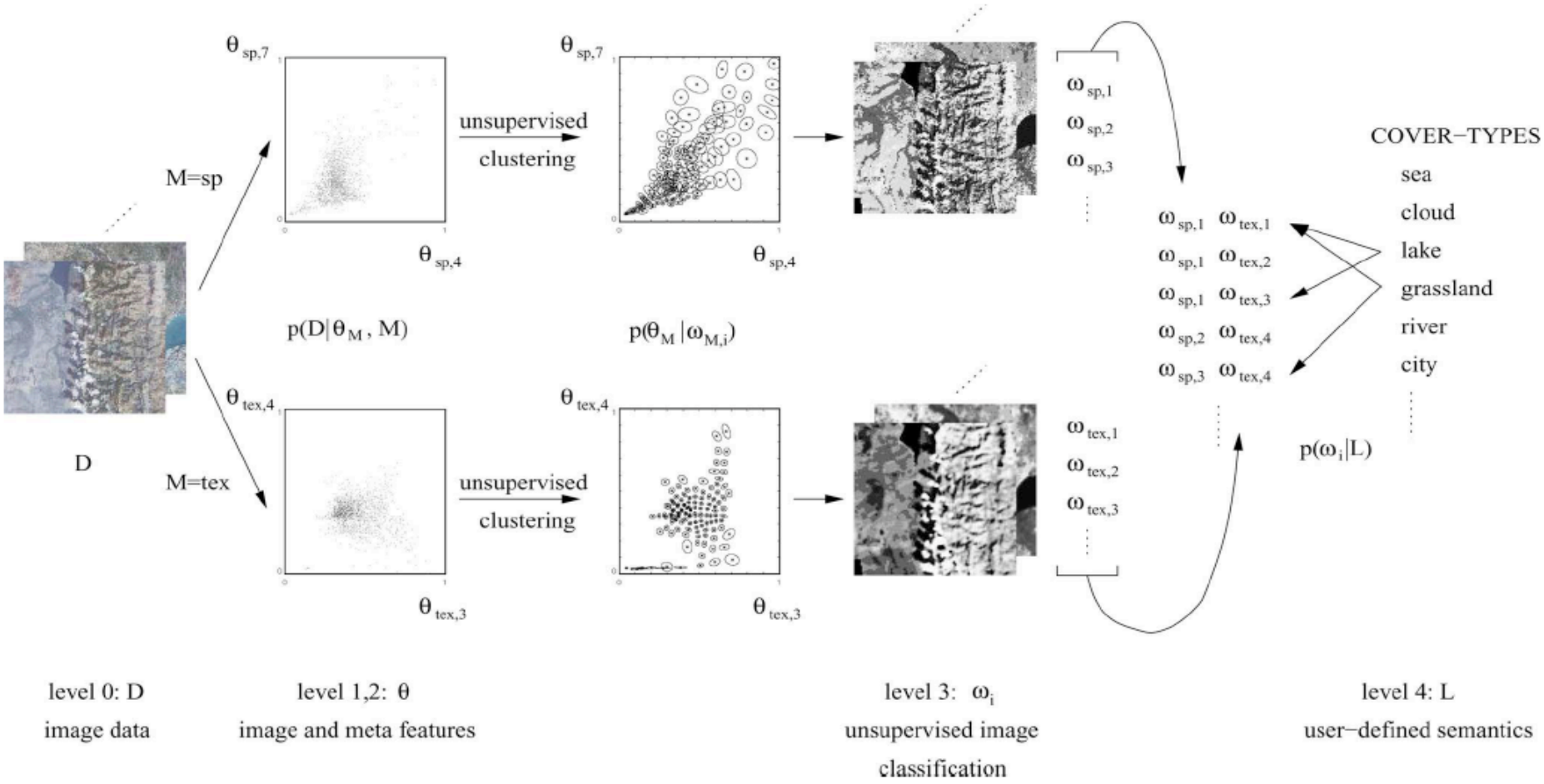
CONCEPT DE COMMUNICATION AVANCE



The principle of semantic compositionality:

the meaning of a whole is a function of the meanings of its parts and their mode of syntactic combination

KIM hierarchical information representation: coding



Coding

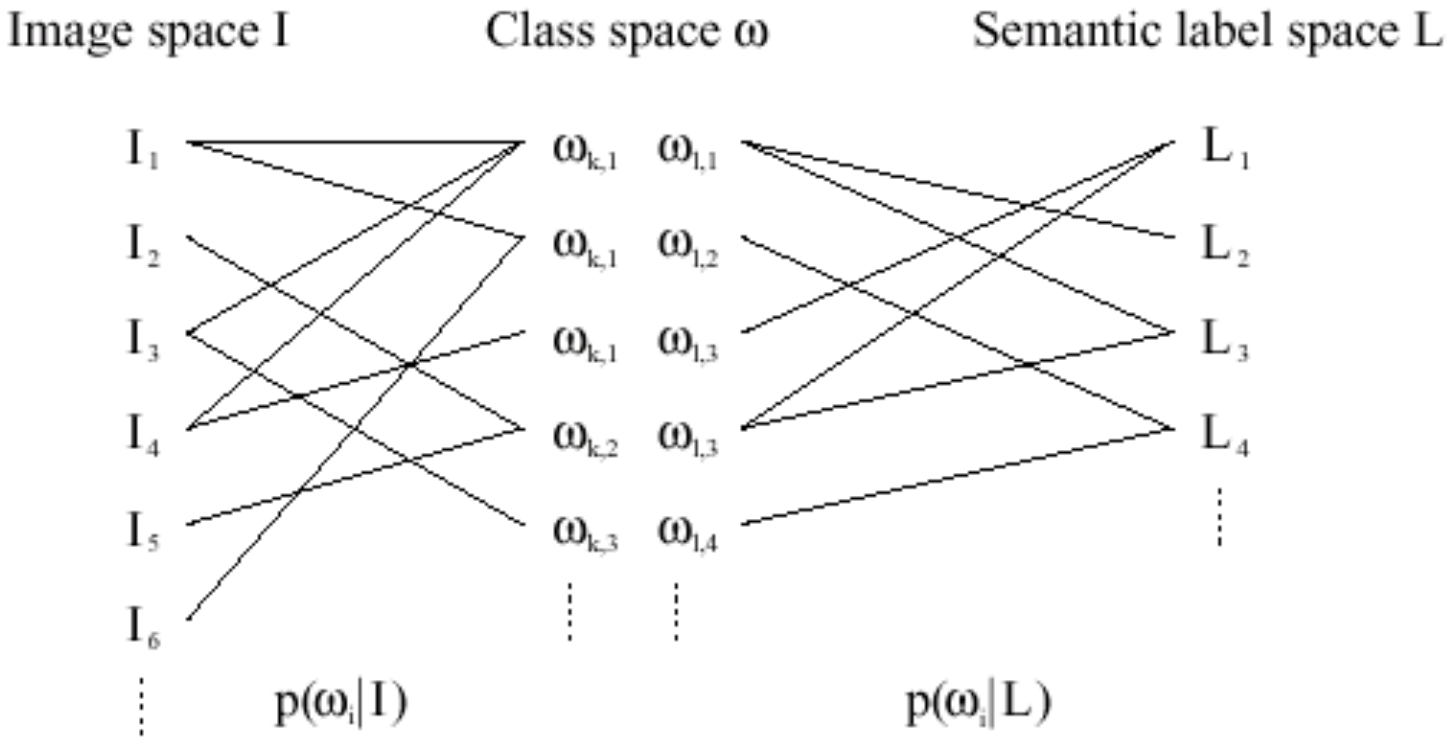


Image space I
Class space ω
Semantic label space L
I1
I2
I3
I4
I5
I6
ωk,1
ωk,1
ωk,1
ωk,2
ωk,3
ωl,1
ωl,2
ωl,3
ωl,3
ωl,4
L1
L2
L3
L4
p(ωi|I)
p(ωi|L)

Semantic coding: Dirichlet model

- after N_i instances the likelihood is

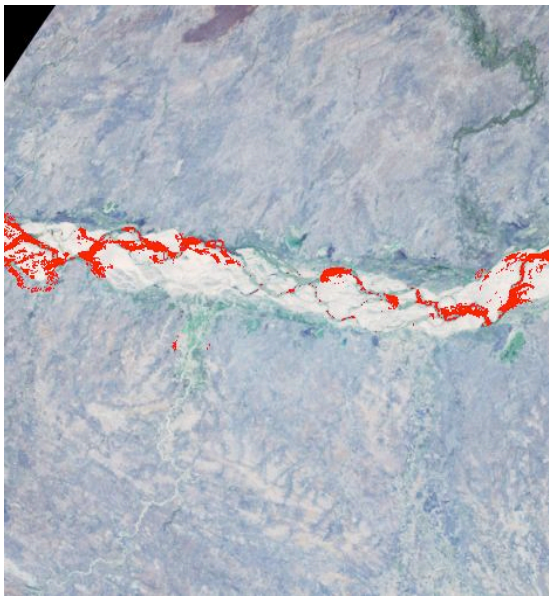
$$
\begin{aligned}
p(\boldsymbol{\theta}|T) &= \frac{p(T|\boldsymbol{\theta}) \cdot p(\boldsymbol{\theta})}{p(T)} \\
&= \frac{\Gamma(r+N)}{\prod_i \Gamma(1+N_i)} \prod_i \theta_i^{N_i} \\
&= \mathrm{Dir}(\boldsymbol{\theta}|1+N_1, \ldots, 1+N_r)
\end{aligned}
$$

$$
\begin{aligned}
p(\boldsymbol{\theta}|T', T) &= \frac{p(T'|\boldsymbol{\theta}, T)\, p(\boldsymbol{\theta}|T)}{p(T', T)} \\
&= \mathrm{Dir}(\boldsymbol{\theta}|\alpha_1 + N'_1, \ldots, \alpha_r + N'_r)
\end{aligned}
$$

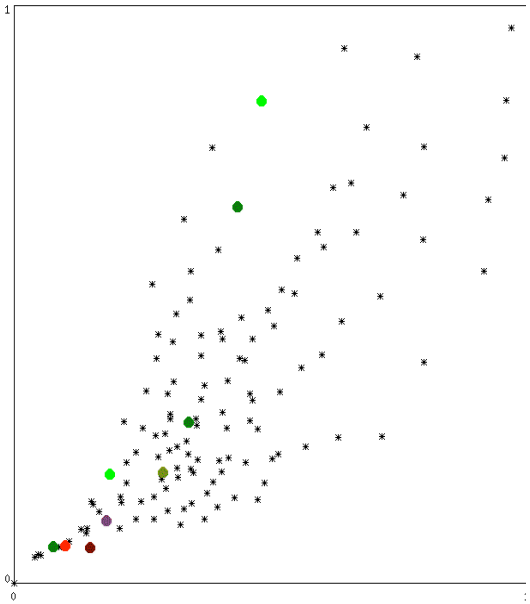
$$
p(\omega_i|A_\nu, T) = \frac{\alpha_i}{\alpha}
$$

Semantic coding

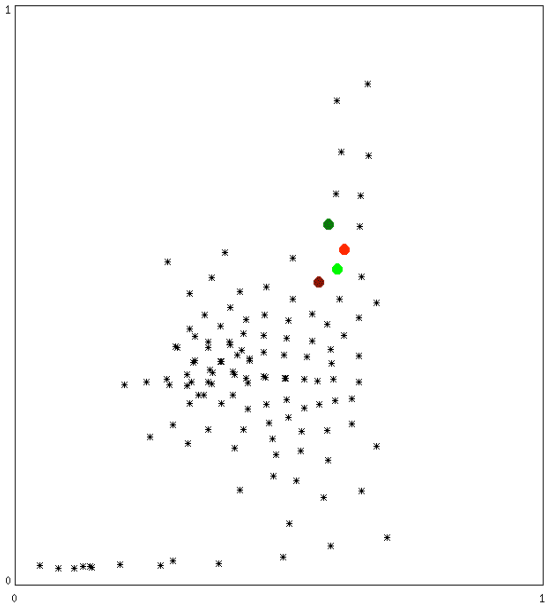
river



spectral

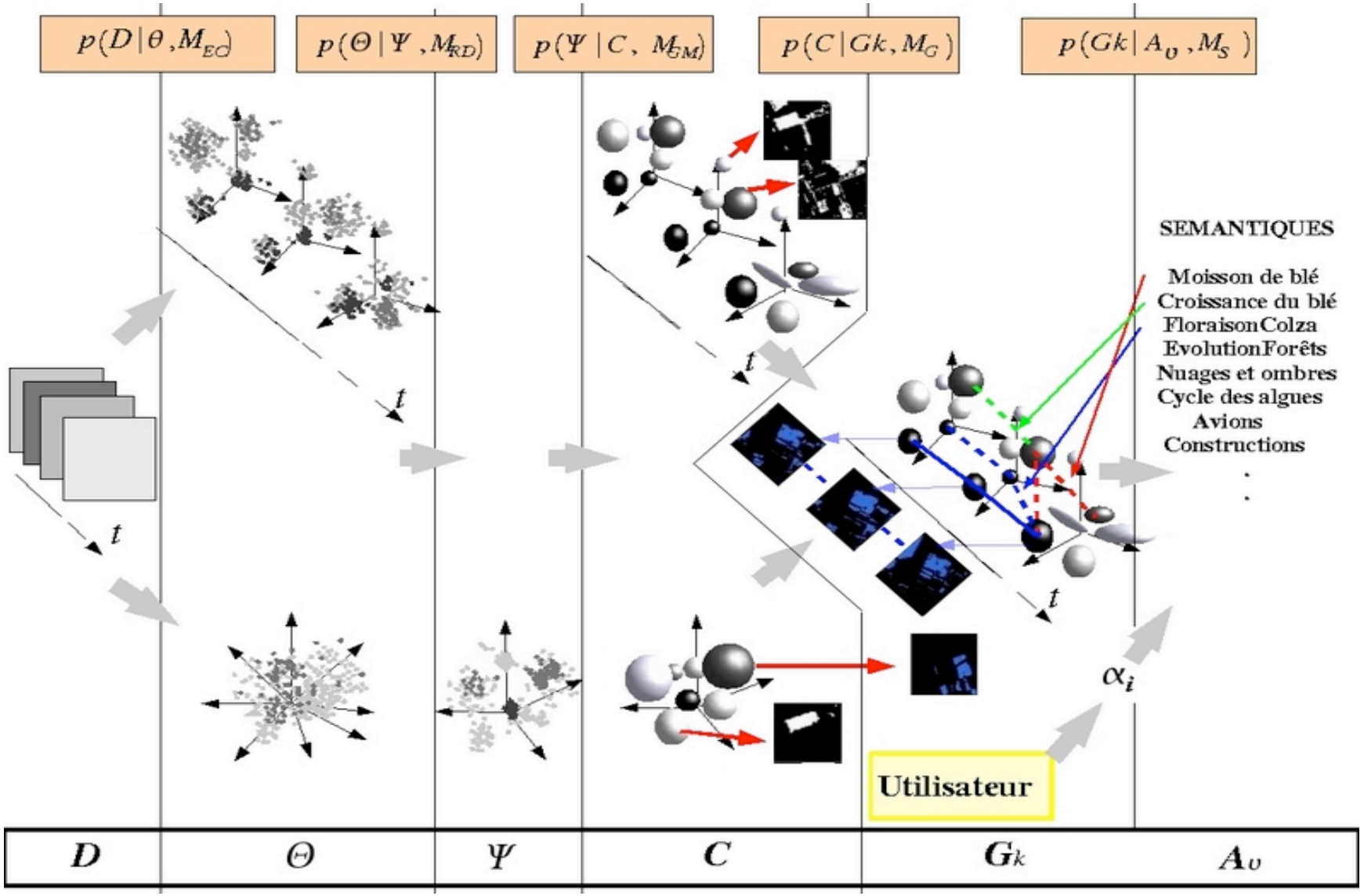


texture

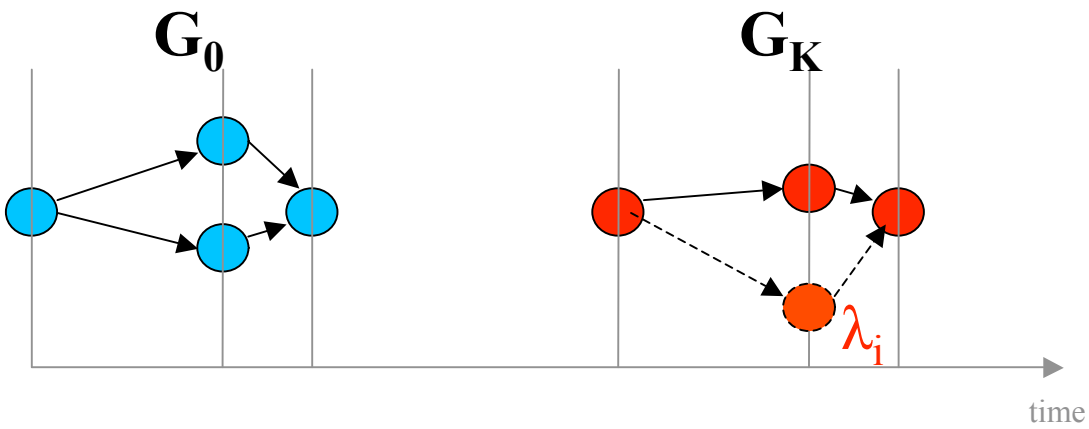


Satellite Image Time Series (CNES, SPOT images, Bucharest)

Spatio-temporal data modelling



Semantic coding



- On définit une **transformation composée d'opérations élémentaires**

$$f : v^0 \rightarrow v^{k\lambda} = v^k \cup \lambda$$

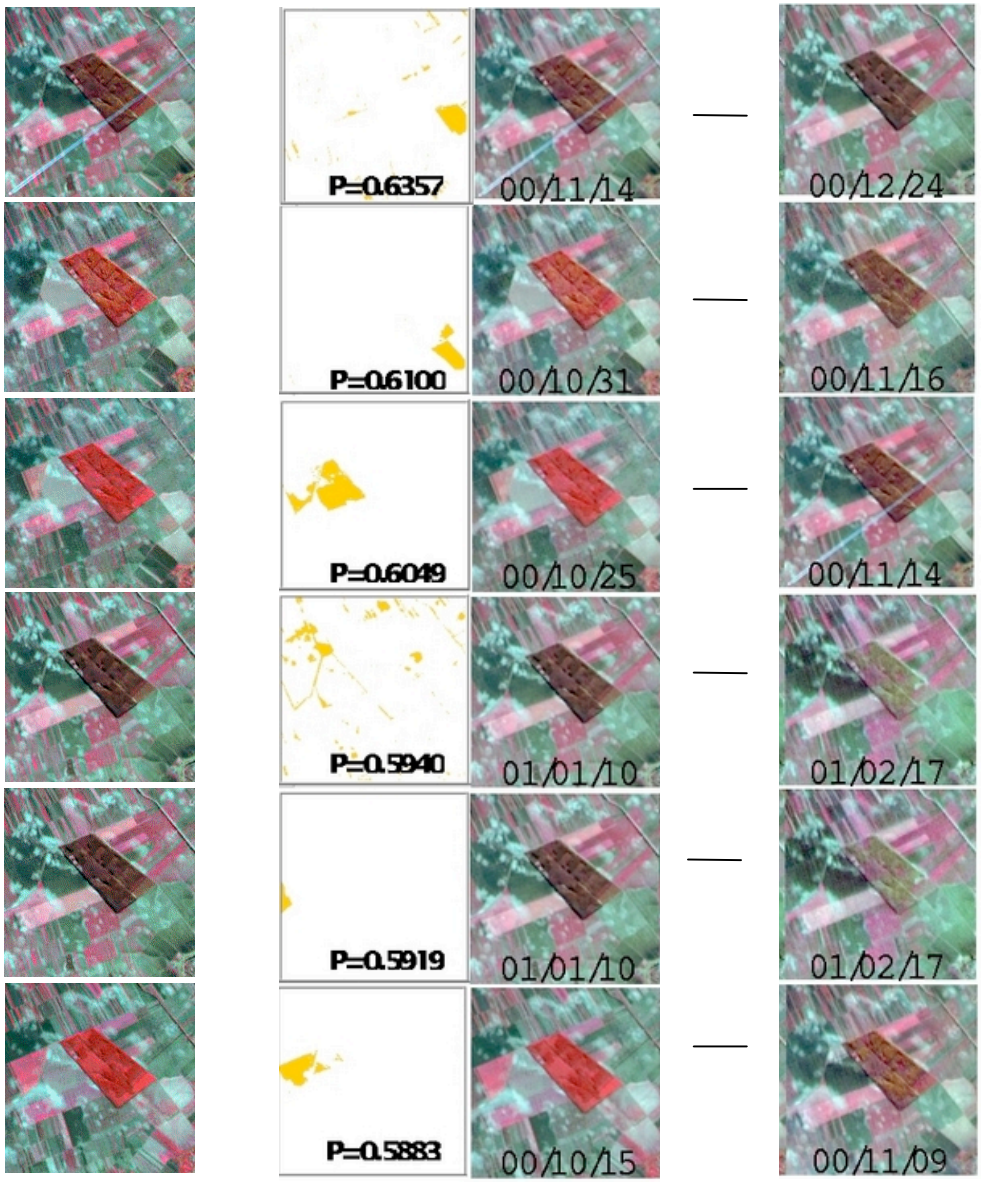
de coût égale à une **somme pondérée de coût partiels** relatifs aux similarités entre les différents attributs de graphes (différence, divergence de Kullback-Leibler) :

- **Apprentissage interactif de la distribution p(ω | T)**

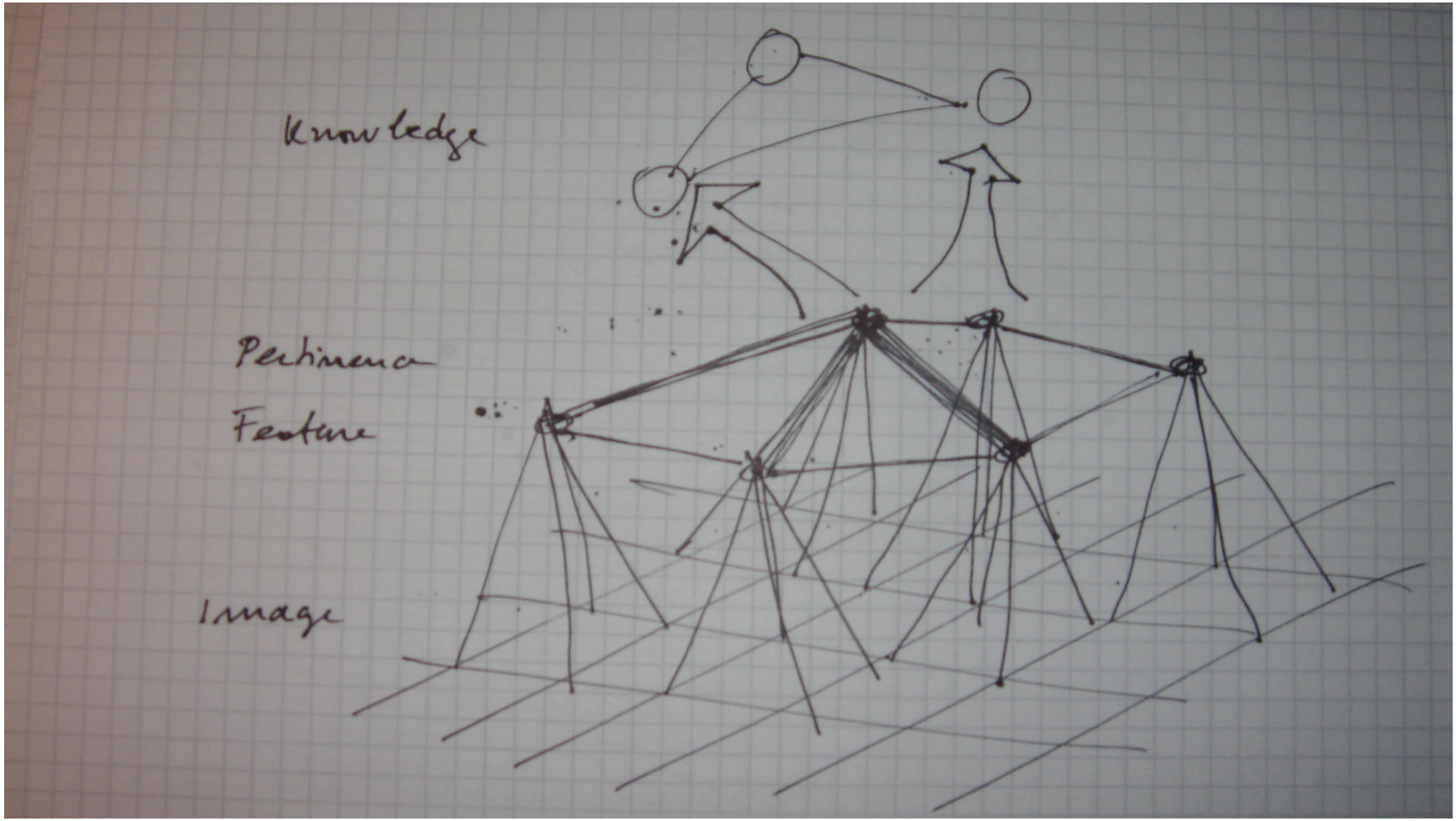
a priori conjugué de **Dirichlet** : p(ω)

$$p(\omega|T^{(1)}) = \mathrm{Dir}(\omega|1+N_1^{(1)}, \ \ldots \ ,1+N_r^{(1)}).$$

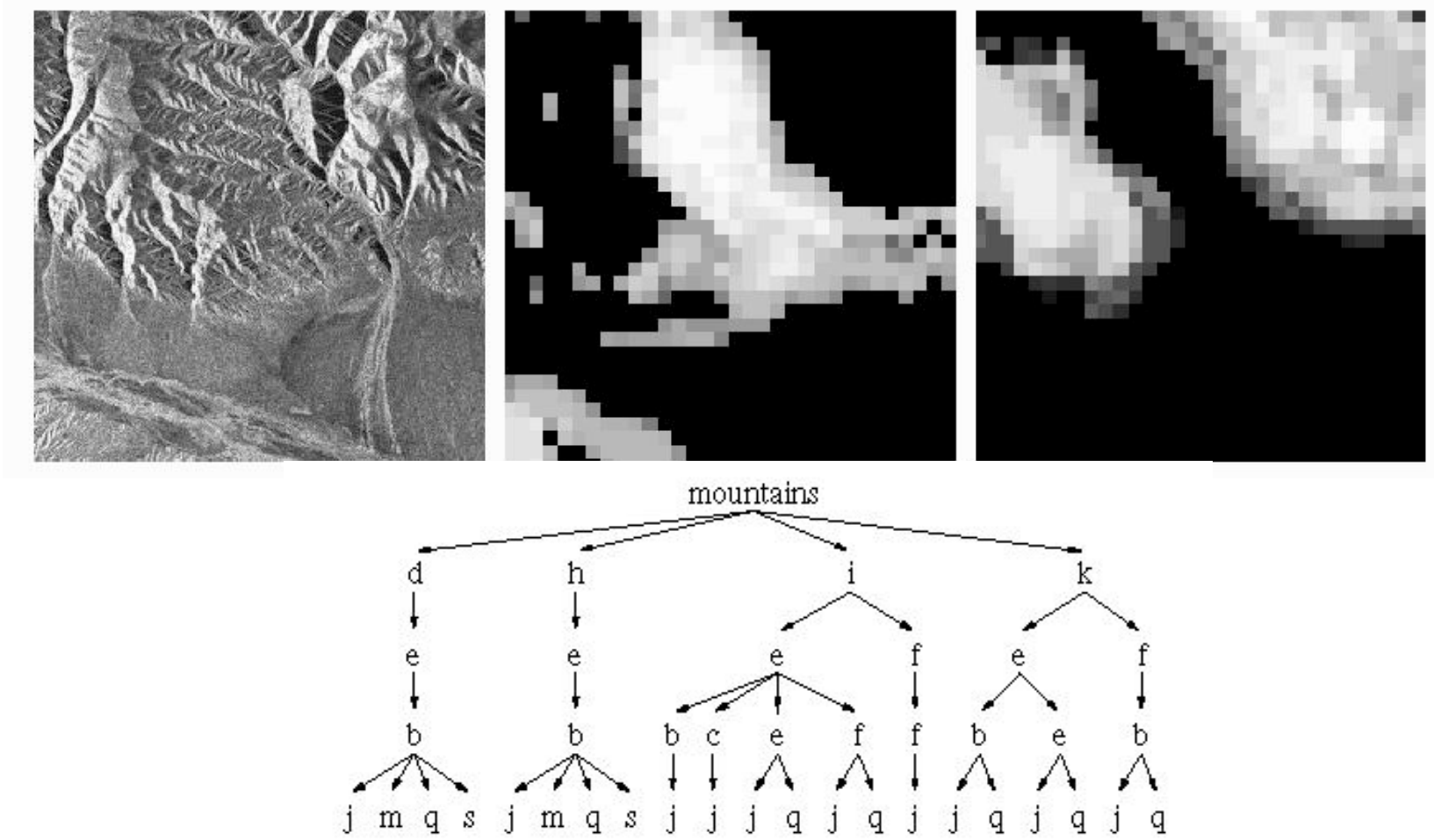
Semantic coding



Spatial semantic coding



Spatial Semantics based on a syntax model



Overview

Stochastic modelling: telecommunications, geosciences, bio-medicine, multimdeia, social and economic sciences, etc.

Image information: acquisition, processing, visualization, and analysis of spatial information. Thus modelling and understanding.

Statistical modeling: discover regularities in observed data. The more regularities are found in the data, the more data can be compressed. Finding regularities in the data means nothing else but to learn about the data.

Links between stochastic modelling, information theory, and machine learning, provided new basic theories for information processing and understanding.

Publications

- M. Datcu, K. Seidel, 2005, *Human Centered Concepts for Exploration and Understanding of Images,* IEEE Trans. on Geoscience and Remote Sensing, ISSN 0196 2892, Vol. 43, No.3, pp. 601- 609
- M. Datcu, H. Daschiel, et al, 2003, *Information mining in Remote Sensing Image Archives: System Description,* IEEE Trans. on Geoscience and Remote Sensing, ISSN 01 96 2892, Vol. 41, No. 12, pp. 2923 - 2936.
- H. Daschiel, M. Datcu, 2005, *Human machine interaction for Image Information Mining*, IEEE Trans. on Multimedia, ISSN 1520-9210, Vol. 7, No.6, pp. 1036-1046.
- P. Heas, M. Datcu, 2005, *Modelling trajectory of dynamic clusters in image time-series for spatio-temporal reasoning,* IEEE Trans. on Geoscience and Remote Sensing, ISSN 0196 2892, Vol. 43, No.7, pp. 1635- 1647.